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Analysis of Risk Factors for Public Private Partnership (PPP) Projects in Construction Industry using Analytical Hierarchy Process (AHP)

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Abstract— ***To fulfil the increasing demands of the public, Public Private Partnership (PPP) has been increasingly used to procure infrastructure projects. However, the risks involved in PPP projects are unique and dynamic due to large amount of investment and long concession period. This causes many challenges like cost overruns, time overruns and lower quality. Risk management is a crucial part of PPP projects. It is important to accurately identify and evaluate the risks involved in PPP projects due to its immense application in the development of infrastructure. This paper deals with the risk identification and prioritization in PPP projects using Analytical Hierarchy Process (AHP), a Multiple Criteria Decision Making (MCDM) process. AHP is a prioritizing and decision making tool which uses mathematical calculations for judging a set of alternatives. 26 risk factors in PPP projects were summarized from a comprehensive literature review and pilot survey. An AHP questionnaire survey was conducted to get opinion from various stakeholders for their priorities on most important risks on projects in Kerala. Results show that project stakeholders believe that social risks has the crucial effect on project performance in major risk factors. In sub risk factors, social unrest, environmental clearance, availability of funds, operation cost overruns and delay in project approvals/permits were the top priority risks.***

Keywords— Public Private Partnership (PPP) Projects, Risk Management, Analytical Hierarchy Process (AHP), Multiple Criteria Decision Making (MCDM)

I. INTRODUCTION

Risk has become an indispensable part of everyday life. Risk is present in everywhere and every area of life. One such area is construction industry. All construction projects are unique and they carry their own risks. Many construction projects fail to achieve their intended goals, which can be realized in terms of time overruns, cost overruns and poor quality. These failures are due to the presence of risks. Risk has many definitions as per many literature. It is defined as "An uncertain event or condition that, if it occurs, has an effect on at least one project objectives" (PMBOK, 2017). Risk is explained as "A hazard, a probability of it to occur and the potential of losses and resulting gains" (Peckiene et. al., 2013). Another definition of risk is "An uncertain event that, if it occurs, has a positive (opportunities) or negative (threats) effect on a project objective" (Silungwe and Khatleli, 2017).

Sources of risks are generally independent of each other. Sources can be internal (within the project) or external (outside environment). In external environments it can be sub divided into predictable sources and unpredictable sources (unknown uncertainties). Examples of internal sources can be scope changes, time overrun, cost overrun, change in technology, resource failure etc. Predictable sources can be financial, economic, political, regulatory, design or specifications while unknown uncertainties can be acts of God, ecological or safety and health. (PMBOK, 2017).

Government sector with its limited resources finds it difficult to handle growing demands of infrastructure for the country, on its own. Therefore, the Government needs to look into private participation for meeting infrastructure demands. This is where Public Private Partnership Projects (PPP) comes into play. This is a contractual partnership between the public and private sector agencies. They contribute to increase in number of services that can be provided within a given budget.

Risks involved in PPP projects are very significant. Large concession period, huge investments and complex technology make risk management an important element in PPP projects. Risks can be managed, reduced, transferred or accepted, but it can never be ignored. The risks need to be thoroughly analyzed, researched and managed to minimize disputes as well as cost and maximize the value for money. Quantitative analysis of risks in PPP projects provides a very clear picture on the most prominent risk groups. (Gupta et al. 2013)

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Identification and evaluation of risks are inevitable in PPP projects. They play an indispensable role in achieving project objectives. As per literatures, there are several techniques for risk assessment in construction industry. Risk identification can be done through discussion with risk analyst and key members of project team, extensive literature survey and brain storming. Based on publications, questionnaire survey is the typical technique for risk identification in construction industry. (Khosravi et al. 2021). The scope of the study is within Kerala, a state in India.

In the present study, a Multi-Criteria Decision Making Method (MCDM) is employed, i.e., Analytical Hierarchy Process (AHP). AHP is a prioritizing and decision making tool which uses mathematical calculations for judging a set of alternatives (Li and Patrick, 2012). This one is the most frequently used MCDM. The main advantage of this method is to effectively handle both quantitative as well as qualitative aspects of the data.

II. Literature Review

A. Public Private Partnership (PPP) Projects

The Department of Economic Affairs, India defines PPP as "An agreement between appropriate government or a statutory entity or a government owned entity on one side and a private entity on the other for the provision of public assets and/or public services, through investments being made and/or management being undertaken by the private entity for a specified period of time when there is well-defined allocation of risk between the private and the public entity and the private entity receives performance linked payments that conform to specified and pre-determined performance standards measurable by public entity or its representatives".

Key features of PPP projects are listed below:

- Accelerated infrastructure provision through allowing private sector financial participation
- Timely project implementation
- Reduced whole life cost
- Reduced government risk exposure by transferring such risks to private sector
- Improved service quality and innovation through the use of private sector expertise and performance incentives
- Effective management of public funds and reduced corruption by increase in accountability and transparency

A typical PPP structure consists of a number of parties like Government, project sponsor, project operator, financiers, suppliers, contractors, engineers, third parties and customers (Quium, 2011). A typical structure of a PPP project is shown in Figure 1 below. The creation of a separate commercial venture called Special Purpose Vehicle (SPV) is a key feature of most of the PPPs. It is a legal entity that undertakes a project and negotiates contract agreements with other parties including the government. An escrow agent is appointed by the Project Company and lenders for managing an account called escrow account which is account set up to hold funds accrued to the project company.

PPP play a vital role in India. First metro project is a PPP. Mumbai Metro is a Built-Own-Operate-Transfer (BOOT) concession agreement for a period of 35 years. SPV of the project is Mumbai Metro One Private Limited which is a joint venture of Reliance Infrastructure, Veolia Transport and Mumbai Metropolitan Region Development Authority. The Great Indian Peninsular Railway Company and the Power Generation and Distribution companies in Bombay and Kolkata are some of the earliest examples of PPP in India. Since the opening of the economy in 1991 there have been several cautious and tentative attempts to bring investments through PPPs in India. However, most PPPs have been restricted to the roads sector (Monga and Dhawade, 2018)

PPPs existed in India from British's time. But real PPP movement started in 1995 when there is a significant amendment in National Highway Act 1956 to allow private participation. Vinayak Chatterjee (2012) commented that World's largest PPP market is in India. India's PPP market is ten times larger than China, even though China's economy is four times larger than India. (Monga and Dhawade, 2018)

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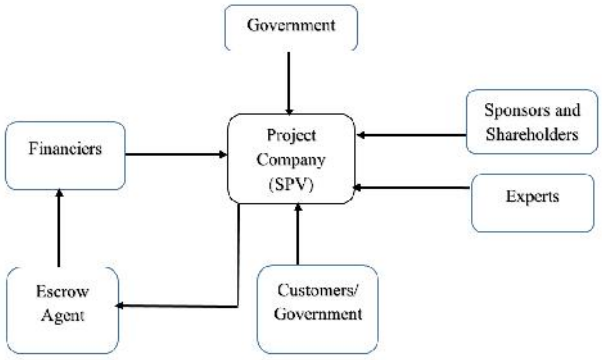

Fig. 1 Typical structure of a PPP project (PPP Guidebook, UN ESCAP, 2011)

B. Risk Factors and Analysis

The PPP involves large number of factors. Each party bear different risks over various phases of life. Risk associated with PPP projects cannot be underestimated due to large investments and longer life of project. Risk profile of PPP projects are entirely different from that of conventional projects.

This paper deals with mainly 8 major risk factors namely, financial risks, legal risks, political risks, economic risks, operation and maintenance risks, construction risks, social risks and relationship risks. Each major risk factors have additional sub risk factors.

Gupta et al. (2013) illustrated that one of the main reason for risks in PPP projects was longer project duration. Highest risk was faced during construction phase. Major risks in PPP projects were legal, social and economic risks.

Valipour et al. (2015) adopted Fuzzy Analytical Network Process (FANP) for prioritizing risks. The results showed that the major risks in PPP projects were financial, political and legal risks. Improper design, change in value of granted land and termination of concession were crucially important sub risk factors.

Khodier and Mohamed (2013) identified top major risks in PPP projects. The major risks were change in currency price, new tax rates, lack of fuel, unsecured roads, official changes, workers' strikes and fire risk. The paper suggested suitable risk response strategies for the identified main risks.

Khahro et al. (2021) recognized that inflation, revenue risk from end user, foreign exchange fluctuations, countries political condition, law and order situation, operation cost overruns, corruption and land acquisition as the crucial risks in PPP.

Ke et al. (2010) showed that public sector would take full responsibility for the expropriation and nationalization risk and other risks related to government or government officials and their actions. There were some risks which were neither the public or private sector may be able to deal with them alone and were preferred to be shared equally like force majeure, tariff change, market demand change etc. Organization and coordination risk, technology risk, cost overrun, time overrun etc. were the risks mostly allocated to private sector.

The main risk factors and sub risk factors under each main risk factor in PPP projects identified through literature survey are tabulated in Table 1 below. Those factors that have been repeatedly identified in the literature are crucial. Those critical risk factors are only taken up for further analysis in this study. The critical factors obtained from the literature survey is cross checked with the results of pilot survey conducted with experts for more accuracy.

There are numerous MCDMs for analyzing risk factors like AHP, Analytical Network Process, and TOPSIS etc. Among them, AHP is efficient. It is a powerful decision making tool invented by Saaty in 1970s. It can be used for prioritizing alternatives based on ratio scale.

Fayek and Eskander (2018) used AHP for risk assessment for Arabian construction projects. They presented financial risk as the first likelihood occurrence in Arabian construction projects, followed by design risks and construction risks.

Askari et. al. (2014) analyzed risks based on how it affects time, cost, scope and quality of project. These are also referred to as the "Project Management Triangle" (PMT). They have only considered five risks in the study, namely, economic inflation, international relations, design failures, communication and lack of attention to contract requirements. Among these five risks, economic inflation affects the PMT greatly.

Almuhisen and Celik (2021) studied PPPs in the context of Jordan. This paper focused on developing a risk assessment model for evaluating risk factors. The most important risk factors for projects in Jordan are Transfer phase, organizational risks, financing phase, management risks and feasibility study phase.

Razi and Ramli (2019) conducted an empirical study on risk assessment delay case study of public road construction in Malaysia. Technical risks bagged with rank one followed by natural hazard and financial risks.

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III. Research Methodology

This paper presents how to properly manage risks in construction industry based on risk assessment formulated on AHP. Extensive literature review was conducted to identify risk factors. Around 96 sub risk factors were identified from literature. These factors were shortlisted to 26 sub risk factors using pilot survey with expert officials. These 26 sub risk factors were categorized under 8 main risk factors. Main risk factors were financial, legal, political, economic, operation and maintenance, construction, social and relationship risks.

AHP questionnaire was prepared for this 26 sub factors and 8 main risk factors. Risk Breakdown Structure (RBS) was prepared and shown in Figure 2 below. The collected surveys were examined using Excel and AHP software. Based on the results, the most important sub risk factor and main risk factor with the highest rank were determined. Ranking was based on local and global weights of each sub risk factors.

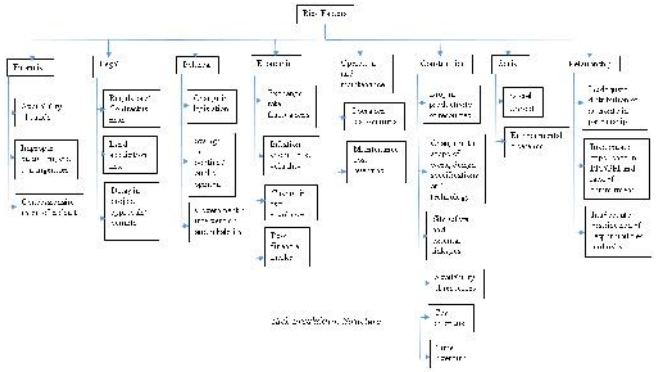

Fig. 2 Risk Breakdown Structure

A. Analytical Heirarchy Process

The Analytical Hierarchy Process (AHP) was developed by Saaty in 1970s. As per Saaty, the first step of AHP is to formulate the decision problem in a hierarchy structure. The fundamental hierarchy structure includes three levels. The second step is to carry out pair-wise comparison where elements in each level are pair-wise compared with respect to their importance to the entire decision problem. After checking the consistency of the pair-wise comparison, the ranking of each element and the priority of alternatives can be computed.

IV. Results And Discussions

AHP questionnaire is prepared for the shortlisted risk factors. A sample questionnaire is given in Appendix. Around 32 responses from officials working in public and private sector across Kerala.

The collected survey is analyzed using Excel and AHP software. Based on the AHP weights, Main risk factors can be ranked. The one with highest AHP weights will be ranked one and will have the highest significance on the project performance. The table below shows the ranking of main risk factors with their corresponding AHP weights.

TABLE I. RANKING OF MAIN RISK FACTORS

Main Risk Factors	**AHP Weights**	**Rank**
Social Risks	0.807	1
Financial Risks	0.244	2
Construction Risks	0.139	3
Legal Risks	0.138	4
Economic Risks	0.129	5
Operation and Maintenance Risks	0.116	6
Political Risks	0.099	7
Relationship Risks	0.053	8

From the Table above, it can be inferred that Social Risks have highest impact on project performance followed by financial risks. Relationship risks have least effect on project performance.

Chandrasekaran and Sreehari (2021) concluded that construction projects affect the local environment of the project area and have significant impact on local population due to social and environmental risks. This will create obstacles in in project implementation leading to cost overruns and time overruns. In the case study of Delhi-Gurgaon Expressway, it could be seen that this large scale projects have capability in displacing and affective a large group of families. Social risks are mainly

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arised due to the poor public consultation during the project development stage. In the case study of Vadodara Halol Toll Road, a significant benefit of the project was the extensive environment and social impact assessment undertaken during the development phase of the project.

For ranking of sub risk factors, sub risk factors under each main risk factors are analyzed separately to obtain local AHP weights of each sub risk factors. This local AHP weights of each sub risk factors is multiplied with the corresponding weight of main risk factors to obtain global weight of each sub risk factors. AHP weights of sub risk factors is given in Table below.

TABLE II. AHP WEIGHTS OF RISK FACTORS

Main Risk Factors	AHP Weights of Main Risk Factors	Sub Risk Factors	Local AHP Weights of Sub Risk Factors	Global AHP Weights of Sub Risk Factors
MR1	0.244188	MR1SR1	0.650523	0.15885
		MR1SR2	0.242909	0.05932
		MR1SR3	0.106568	0.02602
MR2	0.137559	MR2SR1	0.59581	0.08196
		MR2SR2	0.225043	0.03096
		MR2SR3	0.179148	0.02464
MR3	0.099134	MR3SR1	0.435481	0.04317
		MR3SR2	0.368739	0.03655
		MR3SR3	0.19578	0.01941
MR4	0.129053	MR4SR1	0.191314	0.02469
		MR4SR2	0.366804	0.04734
		MR4SR3	0.225992	0.02916
		MR4SR4	0.215891	0.02786
MR5	0.116389	MR5SR1	0.772727	0.08994
		MR5SR2	0.227273	0.02645
MR6	0.139451	MR6SR1	0.275452	0.03841
		MR6SR2	0.236284	0.03295
		MR6SR3	0.173105	0.02414
		MR6SR4	0.135438	0.01889
		MR6SR5	0.076697	0.0107
		MR6SR5	0.103025	0.0144
MR7	0.807345	MR1SR1	0.535316	0.43218
		MR7SR2	0.464684	0.37516
MR8	0.053491	MR8SR1	0.48445	0.02591
		MR8SR2	0.277708	0.01485
		MR8SR3	0.237842	0.01272

Table below shows the ranking of sub risk factors. Social unrest is the major issue affecting project performance. Site safety and external linkages have the least effect on project performance.

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TABLE III. RANKING OF SUB RISK FACTORS

Sub Risk Factors	AHP Weights	Rank
Social unrest	0.432184696	1
Environmental Clearance	0.375160304	2
Availability of funds	0.15884991	3
Operations cost overruns	0.089936923	4
Delay in project approvals/permits	0.081959028	5
Improper budgeting and contingencies	0.059315463	6
Poor financial market	0.047337157	7
Change in legislation	0.043171148	8
Drop in productivity of resources	0.038412057	9
Swings in political/public opinion	0.03655472	10
Change in the scope of work, design and specifications and technology	0.03295004	11
Regulatory/contractual risks	0.03095669	12
Inflation and interest rate volatility	0.029164946	13
Change in tax regulations	0.027861381	14
Maintenance cost overruns	0.026452077	15
Concessionaire event of default	0.026022627	16
Inadequate experience in PPP/PFI and lack of commitment	0.025913473	17
Exchange rate fluctuations	0.024689646	18
Land acquisition risks	0.02464342	19
Cost overruns	0.024139665	20
Government's intervention and reliability	0.019408533	21
Time overruns	0.018886965	22
Inadequate distribution of responsibilities and risks	0.01485474	23
Availability of resources	0.014398316	24
Inadequate distribution of authority in partnership	0.012722288	25
Site safety and external linkages	0.010695459	26

Top risk factors obtained are Social unrest, Environmental clearance, availability of funds, operation cost overruns and delay in project approvals/permits. These sub risk factors should be given top priority while formulating a risk management strategy.

Social unrest and environmental clearance could be clearly seen in the K-Rail or Silver-Line project of Kerala. Silver-Line, a semi-high-speed railway project that would run trains at 200 km/h between the state's northern and southern ends, had sparked protests across Kerala. The state administration claims that the railway line will cut greenhouse gas emissions, while environmentalists have voiced concerns about potential ecosystem harm. They were concerned about the state's waterways, paddy fields, and wetlands being irreversibly damaged. They believe this will result in future floods and landslides. The

project's Rapid Environmental Impact Assessment (REIA) was completed earlier in 2020 by the Thiruvananthapuram-based research institute Centre for Environment and Development (CED). Environmental Impact Assessments were not permitted at the research institute because it was not an authorized agency (EIA). A Comprehensive Environmental Impact Assessment (CEIA) covering all four seasons of the year is required, rather than a REIA covering only one season. REIA report focused on the project's positive elements while disregarding the project's main negative aspects and failing to propose methods to alleviate them. The Silver Line does not run through any designated area such as a national park, wildlife sanctuaries, biosphere reserves, or other ecologically sensitive places, according to the project's Environment Impact Assessment (EIA) report, which was submitted in July 2020.But, the alignment is somewhat parallel to one of the global biodiversity hotspots, the Western Ghats and hence, impacts relating to biodiversity need to be carefully assessed. The villages of Madayipara, Kadalundi, Ponnani, and Thirunavaya are among them. According to K-Rail, 9,314 structures would have to be razed. It is estimated that at least 10,000 families will need to migrate. This amount could be doubled if the Environment Management Plan (EMP) is completed. Proper Social Impact Assessment and Environmental Impact Assessment followed by management plan is required at the development stage of project for mitigating social and environmental risks.

Unavailability of financial instrument will result in difficulty of financing. This is mainly due to the absence of a will organized financial framework. There should be a provision for alternate lenders for ensuring continuous flow of finance.

Delay in getting timely approvals and permits from local government leads to project time overruns and cost overruns. The concessionaire will find it difficult to execute the work within the planned schedule. This risk is not within the limit of concessionaire to avoid.

V. CONCLUSION

This paper formulates a risk assessment model for PPP construction projects using AHP. The findings of this study is limited to road projects and also be applicable to similar scale road construction projects. Social risks are ranked one among the main risk factors followed by financial and construction risks. Social unrest ranked one among the sub risk factors followed by environmental clearance and availability of funds.

AHP approach is a good mathematical tool for assessment and analysis of risk factors. This method helps the decision makers to find solutions for construction problems in a rational and logical manner. Future studies are required to allocate these analyzed risk to mitigate the effects of these risks.

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